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An Evaluation of Environmental Quality: Opportunity Costs of Channelization and Land Use Change in the Floodplain of the Obion-Forked Deer River Basin of West Tennessee

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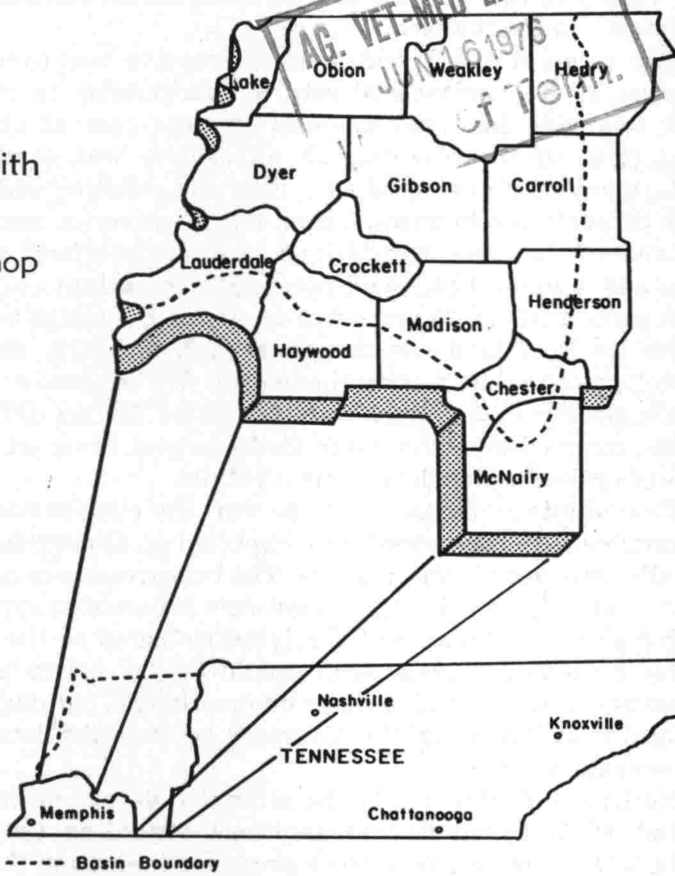

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SUMMARY

THE QUALITY of the environment is a central issue in the controversy over the proposed channelization of the Obion-Forked Deer Rivers of Western Tennessee. Channelization would enhance agricultural production in the floodplain by providing some flood protection and land drainage and represents an enhancement of the environment to certain rural landowners and related agricultural interests. However, sportsmen and other environmentalists find the existing wetlands-forest desirable for their purposes; the transformation and loss of this environment through channelization and following land use changes represent a decrease in environmental quality to these interests. This report is an economic evaluation of these two alternatives.

The value of the development alternative was computed as the change in net agricultural returns attributable to channelization and following land use changes less the cost of channelization. The value of the preservation alternative was computed as the net values of forest products, fish, and wildlife which would be lost through development. These latter estimates were incomplete because of the current inability to predict the effects of channelization and land use change on potentially important parameters.

A project life of 50 years was assumed. Estimates were made for three levels of land use change at 8, 9, and 10% discount rates. Development values were estimated for five assumed crop price sets. While preservation values were estimated for six different sets of value, comparisons were made at the largest value set to reflect the loss of options which development entails.

The results indicated that the current environment should be maintained if crop prices were expected to approximate the three smaller sets used in the analysis. The better resource use would be a matter of judgment if crop prices were expected to approximate the two higher sets because of the incompleteness of the preservation value estimates. Development would be the better alternative if these unquantified, and perhaps unquantifiable, parameters were not judged to at least equal the difference between the development and preservation values.

Noticeable differences in the estimated development values were found when alternative assumptions regarding the benefits attributable to development were employed indicating the importance of proper benefit identification in project evaluation. Substantial

differences between the public and the private costs and returns associated with development were also found suggesting that social control would be required if floodplain resources are to be allocated to the use which makes the greater contribution to society.

The analytical approach used in this study can identify the optimal alternative in a specified set but provides no information to evaluate the possible existence of a superior, unspecified alternative. A second limitation is that this approach does not consider the social acceptability of alternatives which may of necessity involve public restrictions on the rights of private property owners.

Key Words: Channelization, Environmental Quality, Opportunity Cost, Land Use.

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INTRODUCTION

As long as individuals and organizations which represent them have varying opinions on what constitutes the quality of the environment, the enhancement of the environment will be a controversial and frustrating process. This is aptly illustrated by the debate among interested citizens over the use of the land and related water resources of the floodplain of the Obion-Forked Deer Rivers of Western Tennessee.

Floodplain landowners want flood protection and land drainage for crop production while sportsmen and wildlife interests want to maintain the existing fish and wildlife habitat provided by the present wetlands—forest environment.[1] This report is concerned with this problem and is an economic evaluation of potential environmental effects of a proposed channelization project in the Obion-Forked Deer Basin.

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[1] In response to public concern over this issue, the Tennessee Department of Conservation requested the United States Department of Agriculture (USDA) to study the Obion-Forked Deer River Basin Area a) to provide data on the land and water resources of the Basin, b) to assess the needs and potentials of the Area and c) to evaluate alternative proposals for the use and development of the Area's resources. A major concern of the survey was the floodplain where most of the controversy over resource use exists. Participating in the survey were the United States Soil Conservation Service, the United States Forest Service, the Economic Research Service of the USDA, and several State and other Federal agencies. The Soil Conservation Service was responsible for overall leadership. Part of the results of this effort is reported in two interim reports (26) and (27). The Department of Agricultural Economics and Rural Sociology of the University of Tennessee, Knoxville, assisted the Soil Conservation Service in the survey by providing basic information on changes which have occurred in the Area during the 1960 decade. These changes are reported in Badenhop and Thomsen (3).

THE PROBLEM AREA

The Basin

The Obion-Forked Deer watershed is bounded by the Tennessee River divide on the east, the Mississippi River on the west, the Hatchie River divide on the south, and the Kentucky border on the north.[2] The total drainage area is 3,185,000 acres contained in 14 Tennessee counties (Figure 1).

The South Fork of the Forked Deer River originates in the

[2] Hydrologically, the Obion-Forked Deer Basin includes small portions of Fulton County and Graves County, Kentucky. However, the Tennessee-Kentucky border is generally defined as the northern limit of the watershed.

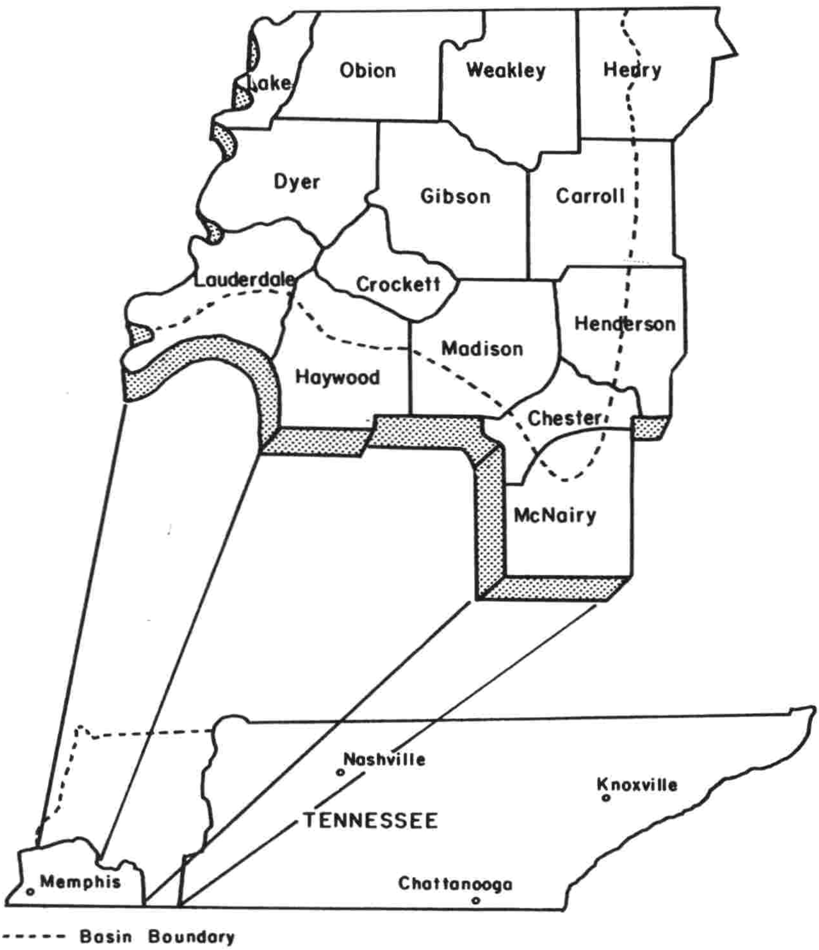

Figure 1. Obion-Forked Deer River Basin.

Tennessee River divide in McNairy County. It flows northwest through Madison County to a point a few miles north of Dyersburg where it is joined by the North Fork of the Forked Deer. This confluence forms the Forked Deer River some 20 miles above its mouth. The Obion River is formed by the junction of its North and South Forks in Obion County. The Obion flows southwest from this point to its confluence with the Mississippi River at Mile 821.4. The Forked Deer River joins the Obion River 3 miles upstream from its mouth. The system contains about 470 miles of stream channels (7, p. 32).

Annual rainfall varies from 32 to 73 inches with an average of 50 inches. Monthly precipitation varies from 3.0 to 5.6 inches. The growing season is approximately 7 months long (2, p. 1).

The Floodplain

The Obion-Forked Deer floodplain is about 2 miles in width in the central portions of the floodplain (Figure 2). The floodplain

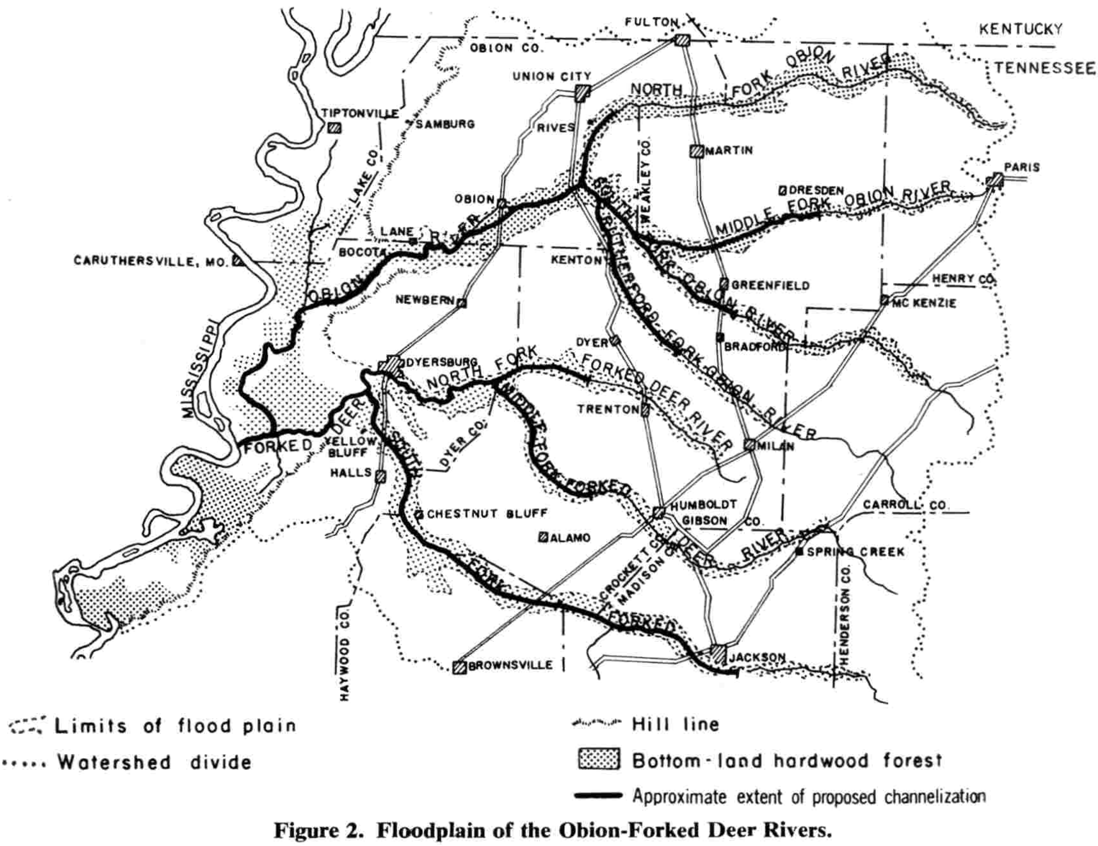

Figure 2. Floodplain of the Obion-Forked Deer Rivers.

encompasses approximately 759,000 acres or approximately 24% of the total Basin. Prior to drainage, the floodplain consisted of an almost continuous expanse of forest and swamp, dotted with ox-bow lakes and sloughs and interwoven by meandering river channels (2, p. 3).

Most of the river channels were dredged in the early part of this century. The channel enlargement reduced flooding, opening substantial portions of the floodplain for cultivation. Concurrently, technological advances embodied in farm machinery made more intensive cultivation of the uplands possible. Soil erosion in the uplands increased, accelerating siltation of the channels. The dredged channels have not been maintained and consequently flooding has increased. Historically, major overflows on the main channels have occurred during the winter months. Flooding occurs most frequently in the upper portions of the main streams and tributaries following heavy rains. These isolated, relatively small floods occur through any given year. An average of 63% of the floodplain experiences at least one overflow annually.

Erosion and siltation are associated with other floodplain problems. The level of the groundwater table has shown a general increase as stream channels have lost capacity through sedimentation. The impact is obvious in low areas where the groundwater table has risen sufficiently to swamp the land; a more subtle, widespread effect is the hindrance of plant growth because of a reduction in soil aeration. Not all silt is deposited in the stream channels; sediment left by receding floodwaters has decreased the productive capacity of many acres of floodplain land. In addition, sediment deposits have formed natural levees along stream courses which cause ponding by impeding the flow of floodwater back into the channel.

Floodplain Land Resources

The USDA has divided the soils of the Basin into seven soil productivity groups. A soil productivity group (SPG) is defined as two or more land capability units which are similar in yield characteristics, fertilizer responses, and management requirements. All of the floodplain soils fall into three groups: SPG-5 (high inherent productivity), SPG-6 (moderate inherent productivity), and SPG-7 (low inherent productivity).[3]

Floodplain land use was mapped from the air in 1971 by updating 1964 aerial photographs. The floodplain was predominately rural: 19,200 acres were dedicated to urban uses, roads, railroads, and the like in 1971 while about 740,000 acres, or 97% of the floodplain was cropland, pasture, forest, and marshland. More than half of the floodplain was cropland and nearly a third was forested. Soybeans were the leading crop, occupying 45% of the total floodplain and 76% of the cropland. Floodplain land use by soil productivity group in 1971 is presented in Table 1.

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[3] The USDA (26, p. 6) describes these three groups as follows:

Soil Productivity Group No. 5—are deep, well-drained to moderately well-drained bottom land soils. Most of this group has a brown, very friable silt loam surface and the subsoil is the same texture except some has gray mottles. They have good tilth, moderate to high natural fertility, and high moisture supply capacity. These soils are capable of high yields of all common crops and timber. Representative soils are Collins, Dekoven, Adler, Morganfield, and Vicksburg.

Soil Productivity Group No. 6—are deep, somewhat poorly-drained bottom land soils. The surface layer is brown but gets grayer with depth and is mottled. Most of the group has a high water table which is near the surface in winter and spring and lowers in the summer. These soils drain readily where outlets are available. With drainage, yields are higher and more consistent but are 10-15% less than crops on SPG-5. These soils are medium in natural fertility and respond highly to fertilizer. Representative soils are Waverly, Iberia, Moon, and Hatchie.

Soil Productivity Group No. 7—are nearly level, poorly drained soils. The surface soil is light gray to dark grayish brown or brown friable silt or sandy loam to over 36 inches. The subsoil is a mottled gray to brown friable silt loam. Surface drainage is low and soils are difficult to drain because outlets are few. Yields of common crops such as soybeans and corn are usually 35-45% less than yields on SPG-5. Representative soils are low Waverly, Beechy, and Swamp.

OBJECTIVES

The Environmental Policy Act of 1969 requires that the evaluation of public project proposals include an assessment of the impact of the project on the environment.[4] This legislation demanded attention in fulfilling the objectives of the USDA Basin survey. Therefore, the objectives of this study were 1) to develop a method of assessing the impact of public projects on environmental parameters, and 2) to evaluate a river channelization project proposed by the U. S. Army Corps of Engineers to enhance the land resources of the Obion-Forked Deer floodplain.[5]

Table 1. Land Use by Soil Productivity Group, Obion-Forked Deer Floodplain, 1971

Land Use	Soil Productivity Group			Total
	5	6	7	
	Acres			
Soybeans	197,910	90,944	53,952	342,806
Corn	14,165	2,645	1,899	18,709
Cotton	11,413	1,813	940	14,186
Pasture	45,184	7,126	4,971	57,281
Miscellaneous cropland [a]	11,306	3,158	3,499	17,963
Total cropland	279,978	105,686	65,281	450,945
Forest	34,965	74,496	121,792	231,253
Swamp	1,835	9,238	32,405	43,478
Wildlife areas [b]	491	4,011	9,856	14,358
Urban	4,437	2,261	491	7,189
Other [c]	4,714	4,737	2,624	12,011
Total	326,420	200,429	232,499	759,298

[a] Includes rice, milo, small grains, truck crops, and idle cropland.

[b] State and Federal areas only, these areas contain an additional 11,500 acres of forest.

[c] Includes roads, railroads, ponds, ditches, and levees.

Source: Derived from U.S. Department of Agriculture, 1972. **Interim Report: Obion-Forked Deer River Basin Survey,** Nashville, Tennessee, p. 7.

THE RIVER CHANNELIZATION PROJECT

Channelization involves straightening, deepening, and enlarging stream courses through dredging and excavation. The frequency, extent, and duration of flooding are reduced because of the increased

[4] The word "environment" has several possible meanings. For this study "environment" was defined as the natural environment, a system encompassing the relations between plant life, animal life, man, and the physical world.

[5] This plan was chosen a) because this channelization proposal is a major issue in the debate over floodplain resource use, and b) no other complete project proposal existed at the time of this study.

channel capacity. Channelization can also enhance the potential productivity of some land by lowering the groundwater table.

Two types of negative environmental effects are associated with channelization. The first is pollution from such sources as silt released during construction and from agricultural chemicals associated with intensified land use following construction. The second is the transformation and loss of an environment because of channelization and the resulting land use changes.[6] Opponents of channelization almost universally base their opposition upon this second effect.[7]

The Corps of Engineers project involves channelization along the main courses and tributaries of the Obion and Forked Deer Rivers for an aggregate length of approximately 160 miles, Figure 2. The project would benefit about 140,000 acres of cropland and permit the clearing of around 18,000 acres of woodland for agricultural purposes (21, p. 11). The project is opposed by sportsmen and other environmentalists who believe that the loss of the current wetlands ecosystem represents an environmental cost which exceeds the benefits of the project.

The Impact on Environmental Quality

Environmental quality may be defined as an individual's judgment on the suitability of a natural resource or group of resources for a specific purpose.[8] The transformation and loss of the existing wetlands-forest environment through channelization and following

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[6] A relatively large body of economic thought concerning pollution problems exists. For a review of current literature in this area, see Mishan (15). In contrast, the second type of environmental effect has received little attention. Fisher, Krutilla, and Cicchetti (8, p. 605), for example, state:

> where reference is made to the despoliation of natural environments, note is made only in passing of "extra-economic" considerations. Similarly in texts on land economics no mention is made of the economic issues involved in the allocation of wildlands and scenic resources, nor do the costs of land development include the opportunity returns foregone as a result of destroying natural areas.

[7] During a recent series of Congressional hearings on stream channelization (24) the pollution issue was rarely raised by opponents of the practice. Harnik (10) summarizes many of the arguments against channelization presented in these hearings.

[8] This definition of environmental quality has been suggested by North (18). The chemical, physical, biological, economic, social, and aesthetic characteristics of the resource would be factors in this judgment. Judgments on the quality of a resource may vary among people because of individual differences. Also, an individual's evaluation may change over time because of changed circumstances and/or personal changes.

land use changes would make the floodplain less suitable for the purposes of sportsmen and other environmentalists. At the same time, however, the flood protection and land drainage which channelization offers would make the floodplain more suitable for agricultural purposes.

The problem is that the purposes of both interest groups are socially desirable but involve incompatible floodplain land uses. This study was based on the proposition that the floodplain lands should be dedicated to the use which makes the greatest contribution to society as a whole.

PROCEDURE

Benefit-cost analysis is a commonly used technique in public project evaluation. It is argued that if the ratio of the estimated costs of the project to the predicted benefits exceeds 1.0, the project will make a net contribution to society and should be undertaken.

One criticism of benefit-cost analysis is that many environmental products are not traded in the market place and thus do not have established prices.[9] These products do, however, have a value to society and their modification or loss represents a cost which should be included in the analysis. Attempts have been made to impute prices to these products; however, our current knowledge about the environment is incomplete.[10] We are often unable to predict the magnitude of the impact of a project on environmental parameters.

Also, potentially important parameters, such as the satisfaction some people derive from the mere knowledge that a natural state is being maintained or the value of archeological sites, are poorly understood. Such parameters currently defy measurement and, perhaps, are unmeasurable. The probability of an incomplete estimate of the costs associated with a project led to a search for another method of evaluation.

Among others, Krutilla (13) has suggested the comparison of the opportunity costs of alternative resource allocations.[11]

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[9] The terms "environmental product" and "environmental parameter" are used interchangeably in this study. The products or parameters of the environment include commodities, such as timber; services, such as the biological degredation of wastes; and attributes, such as the scenic properties of a landscape.

[10] The practice of imputing values to environmental products which do not have prices established through market transactions has been criticized as a mythical exercise; see, for example, Moody (17, pp. 188-189). Since values were imputed to nonmarketed products in this analysis the study is open to criticism on this point.

[11] An opportunity cost is a foregone return; the value of a product not produced because the resources were used in a different alternative. Coase (6, p. 43) argues that an evaluation of opportunity costs is a desirable approach to any policy question involving "alternative social arrangements."

Let us assume that it is not possible to adequately estimate the environmental costs associated with a project. If the returns foregone as a result of undertaking the project are greater than the returns from the project, the project should not be undertaken. A complete estimate of the foregone returns would only increase the opportunity cost of the project and strengthen this conclusion. If, on the other hand, the returns foregone as a result of undertaking the project are less than the estimated returns from the project, the decision becomes a matter of judgment because of the incompleteness of the opportunity cost estimate.

The project should be undertaken if the value of the unmeasured, and perhaps unmeasurable, environmental parameters are not judged to at least equal the difference between the returns from the project and the returns foregone because of the project. The project should not be undertaken if the opposite judgment is made. Thus, while the analysis may be inconclusive, it does set boundaries for the resource allocation decision by establishing a lower limit against which educated opinion and judgment may be evaluated.

The opportunity cost approach was used in this study.[12] The analysis was based on the proposition that resources should be committed to their higher use value and that such an allocation will result in a net increase in environmental quality for society as a whole. The analysis involved estimating the value of the floodplain lands allocated to agriculture following channelization and the value of these lands which would be lost if the area were dedicated to agriculture.

Two weaknesses of opportunity cost analysis should be noted. First, this technique can only identify the optimal choice in a specified set of alternative resource uses. A superior, unconsidered alternative may exist but the technique offers no information to evaluate this possibility. Second, the gains and losses involved in an alternative rarely correspond—those who gain do not automatically bear associated losses and those who lose do not automatically receive compensating benefits. It is generally assumed that a dollar gain or loss by an individual is a corresponding gain or loss to society and this assumption was made in this analysis. However, the validity of decisions involving this assumption may be questioned.

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[12] Several alternative methods of analysis were considered in reaching the decision to employ the opportunity cost approach to the problem. For a discussion of these alternatives, see Smith (20, pp. 14-22 and 106-110).

The Value of Land in Alternative Uses

Let us assume a parcel of floodplain land with several possible uses. The individual owner would rationally dedicate this land to the use which promises the greatest net return. The private value of land may then be defined as the present value of the stream of expected net returns from the land dedicated to its highest use value.

Flooding is one factor which will affect the returns expected from alternative land uses and, thus, land values. Further, a change in the probable frequency and/or duration of flooding can alter the possible uses of a parcel of land and thus change its value. Let us assume, for example, that the best use of a given parcel of floodplain land under the current flood probability is for timber production. The private value of this land would equal the present value of the net returns from exploitation of this timber resource. Let us also assume that the channelization of the adjacent streambed would reduce the frequency and duration of flooding sufficiently for soybean production to become the best land use, that is, for the expected net returns from soybean production to exceed the expected net returns from timber production and all other possible uses. The gross value of this project to the landowner would be the difference between the present value of the expected post-channelization returns and the expected pre-channelization returns. The private net value would then equal this difference less the costs of channelization to the individual. The landowner would rationally support the channelization project if his expected net return after channelization less his costs for the project exceeds his expected net returns before channelization.[13]

The net returns accruing to an individual landowner are determined by the prices established through exchanges in the market. In perfectly functioning markets, private costs and returns equal social costs and returns because a price is attached to all positive and negative effects of individual action. However, if externalities exist, private costs and returns and social costs and returns will not coincide.[14] Decisions made on the basis of market determined prices

[13] These arguments draw extensively on Brown (4). They are expressed in functional terms in Appendix A.

[14] An external economy is said to exist when one person's actions benefit others but he receives no payment in return. An external diseconomy is said to exist when one person's actions are detrimental to others without commensurate costs to the individual. Individual actions which appear to be personally optimal would not be socially optimal since the individual would not include the value of these services and/or disservices into his calculations.

will then not be optimal for society as a whole. In this study, the social value of land was estimated by imputing values to the externalities associated with the alternative land uses.

Social Land Value Estimations

A number of potential external effects were examined. The results of this exercise were three groups of externalities.[15]

Estimated Externalities

These external effects included the value of the change in productivity of the bottomlands forest because of the altered water relations following channelization, and the value of fish and wetlands wildlife lost as a result of channelization and land use change.

Unestimated Externalities

Several externalities associated with channelization and land use change were not quantified because of a current lack of knowledge about the magnitude of the effect and/or unquantifiable aspects of the externality. These externalities included 1) the impact on the Mississippi Flyway; 2) vicarious consumption of a preserved environment; 3) the preserved environment as a source of genetic material; 4) the value of furbearers; and 5) the value of the preserved environment as an outdoor laboratory for the training of future scientists.

Externalities Eliminated by Assumption

Three potential external effects were assumed to be nonexistent because of a lack of evidence about their existence and/or conflicting evidence. These externalities were: 1) the impact of land use change on upland wildlife; 2) the effect of rural stream modification on nonagricultural flood damage; and 3) the effects of the project downstream from the confluence with the Mississippi River.

The components of the social value of land in the two alternative uses which were identified for this study are summarized in Table 2. If the land were developed for agriculture following the channelization project, the net returns accruing within society would equal the value of the increment in agricultural production less the associated production costs and the costs of the project. The opportunity cost of this land allocation, the preservation value, would equal the net value of the timber which would have been

[15] The primary sources of information used were a draft article by Brown (4), a survey article by Harnik (10), and the transcript of a series of Congressional hearings on stream channelization (24). A more detailed discussion of the items in these groups is presented in Smith (20, pp. 28-33).

Table 2. Components of the social opportunity costs of floodplain land in alternative uses [a]

Net Development Value	Preservation Value	Unquantified Environmental Parameters
Increased Yield on Current Cropland	Yield of Forest Products on Land Converted to Crops	Impact on Mississippi Flyway
Yield on Developed Wetlands	Reduced Yield of Remaining Forest	Wetlands as a Source of Genetic Materials
Channelization Cost Parameters: —Design and Construction —Land —Channel Maintenance	Foregone Recreation: —Fishing —Hunting —General Recreation	Wetlands as an Outdoor Laboratory Foregone Furbearers Vicarious Consumption of Wetlands

[a] In identifying the better alternative, if the estimated value of column two exceeds column one, the area should be maintained as wetlands; if the estimated value of column one exceeds column two the area should be maintained as wetlands only if the value of the unquantified, and perhaps unquantifiable, parameters in column three is judged to at least equal the difference between the net development value and the incompletely estimated preservation value.

produced if the land were not cleared for agriculture plus the value of the externalities associated with channelization and land use changes.[16]

Estimating Procedure

The net development value was estimated as the value of the change in agricultural production attributable to channelization less the costs of producing this increment and the costs of the project. The calculations involved predicting the post channelization crop yields and land use patterns, estimating the market value of

[16] The information presented in Table 2 implies that no socially significant externalities are associated with the use of the floodplain land for agricultural purposes. Likely diseconomies include pollutants from such sources as agricultural chemicals, animal by-products, and the residuals of "final" consumption. However data are lacking, as Langham (14, p. 1) notes "often we do not know how to measure the real effects of pollution on parties involved in and influenced by pollution . . . we have done very little to systematically record observations on pollution processes." Turning to external economies, vicarious consumption may be associated with the developed environment; given the world food shortage, an individual may derive satisfaction from the mere knowledge that world food production capacity has been enhanced even though he derives no tangible consumption benefits from the increased production. The procedure followed will underestimate the net development value if significant external economies are associated with the use of the land for agricultural purposes. Conversely, the net development value will be overestimated if socially significant diseconomies are associated with this alternative.

the changes in yield and the costs of their production, and estimating the costs of the channelization project. The equations used in these computations are presented in Appendix A and the sources of the required data are presented in Appendix B. Net values of development were estimated for the five crop price sets presented in Table 3.

Table 3. The agricultural output price sets used in the estimation of the net value of development

Price Set	Soybeans (bu.)	Corn (bu.)	Cotton (lb.)	Pasture (grazing day)
			Dollars	
Low	2.50	1.20	0.22	0.10
Low Median	3.25	1.45	0.265	0.125
Average	4.00	1.70	0.31	0.15
High Median	4.75	1.95	0.365	0.175
High	5.50	2.20	0.40	0.20

The preservation value was estimated as the net value of the environmental products which would be lost if the project were undertaken; that is, the opportunity cost of channelizing the Obion-Forked Deer stream channels and agricultural production in the floodplain. The calculations involved predicting the impact of this allocation of resources on floodplain forests, fish, and wildlife and estimating the value of the foregone environmental products and the associated costs of production. The concept of the maximum sustained yield of a renewable resource was used in valuing these products.

The value of an acre of forest to society was defined as the net annual returns from the maximum sustainable forest production; that is, the average annual net increment in growth of the Obion-Forked Deer floodplain forest. Three stumpage prices were used in valuing this net growth, see Table 4.

The fish and wildlife were valued by estimating their sustained productivity, converting these estimates into recreation activity days, and valuing these activity days. Sport fishing, small game hunting, and general recreation were assumed to be non-specialized recreation while waterfowl and big game hunting were judged to be activities involving relatively limited opportunities and were valued as specialized recreation. The values proposed by the Water Resources Council (WRC) for a specialized and non-specialized recreation day were used in activity valuation (28, p. III-17). Specialized recreation was also valued at the higher levels recommended by the University Council on Water Resources (UCOWR) (5, p. 15). The resulting six sets of values used in estimating the value of preservation are presented in Table 4. The equations used in these computations are presented in Appendix A and the data sources are discussed in Appendix B.[17]

Table 4. The value sets used in the estimation of the value of preservation

Valuation Day	Forest Products (Cubic foot)[a]	Non-Specialized Recreation Activity Day [b]	Specialized Recreation Activity Day [c]
		Dollars	
Low (WRC)	0.23	0.75	2.50
Average (WRC)	0.26	1.50	4.75
High (WRC)	0.29	2.25	7.00
Low (UCOWR)	0.23	0.75	15.00
Average (UCOWR)	0.26	1.50	17.50
High (UCOWR)	0.29	2.25	20.00

[a] Stumpage values per cubic foot in 1971 dollars as computed with the wholesale price index for lumber and wood products (25, p. 552).

[b] Includes sport fishing, small game hunting, and general recreation.

[c] Includes big game hunting and waterfowl hunting.

Sources: Forest Products values derived from Barstow, C. J. 1970. **Fish and Wildlife Resources: Obion and Forked Deer River Basin, Tennessee (Preliminary Report),** Tennessee Game and Fish Commission, Nashville, Tennessee, p. 25 and U.S. Department of Agriculture, 1972. **Interm Report: Obion-Forked Deer River Basin Survey,** Nashville, Tennessee, p. 23.

WRC non-specialized and specialized recreation activity day values derived from U.S. Water Resources Council, 1970. **Standards for Planning Water and Land Resources,** National Technical Information Service, Springfield, Virginia, p. III-17.

UCOWR specialized recreation activity day values derived from Butcher, W. R., B. Rettig, and G. M. Brown, 1971. **Proposed New Procedures for Evaluating Water and Land Resources: Some Comments from an Academic Viewpoint,** State of Washington Water Research Center Pullman, Washington, p. 15.

Discounting Procedure

All computations were made in present value terms to compare values accruing at different times.

Discount Rates. Among recent estimates of the social rate of discount, Eckstein (23, pp. 56-57) has estimated the opportunity cost of public funds raised through taxation and arrived at a rate of approximately 8%. Harbinger (23, p. 63) arrived at a similar discount rate through the estimation of the opportunity cost of borrowing by the public sector. Seagraves (19) has estimated social rates of discount between 8 and 13.2% through imposing various

[17] Preservation value computations were based upon estimated sustained productivity under current conditions rather than potential productivity under intensive management to avoid possible unrealistic over-inflation of the value of renewable wetlands resources.

levels of adjustment on the returns from Class A corporate bonds. Based upon these studies, discount rates of 8, 9, and 10% were used in the analysis.

The Planning Horizon. While the physical effects of channel modification may persist for 100 years or more, the relevant time horizon for this analysis was the economic life of the project. The effective economic life was estimated by determining the time at which the discounted value of $1 was essentially equal to zero; a present value of $0.01 was considered to be an equality (8, p. 613). One dollar has a present value of $0.01 at approximately 53 years with a 9% rate of discount.[18] A 50-year planning horizon was, however, used for convenience in computation. A 50-year span has the additional advantage of corresponding with the mandatory planning horizon of the USDA survey of the Obion-Forked Deer Basin.

The year 1971 was used as the base year for the planning horizon, and all values were calculated in 1971 dollars.

The Cases Analyzed

The net development value and preservation value were estimated for three assumed levels of wetlands conversion. Each represented an increase in wetlands conversion relative to the prior case.[19]

Case I. Estimates were calculated for the land expected to be benefited by the project. The project is expected to enhance the productivity of 140,140 acres of cropland and allow the conversion of 17,690 acres of forested wetlands, including 2,740 acres of woodlands above the limits of overflow, to agricultural use (21, p. 11). The areas involved were estimated to be 86,554 acres of SPG-5 cropland, 53,586 acres of SPG-6 cropland, and 17,690 acres of woodlands on SPG-5 soils.

Case II. It was assumed that all privately owned wetlands forest on SPG-5 and SPG-6 soils would be converted to agricultural use. Five distinct categories of land are involved: 1) the SPG-5 land in cultivation prior to channelization and enhanced by the project, 2) the SPG-6 land in cultivation prior to channelization and enhanced by the project, 3) the converted SPG-5 wetlands protected by the

[18] The formula is $0.01 = 1.00/(1 + r)^t$ where r is the discount rate and t is the time in years. When the discount rate is eight percent, $1.00 accruing approximately 59 years in the future has a present value of $0.01. At 10% the time span is about 48 years.

[19] These cases implicitly assume that the channelization project is the cause of land use change. An alternative hypothesis is examined in Appendix C.

project, 4) the converted SPG-5 wetlands not protected by the project, and 5) the converted SPG-6 wetlands. The areas in the first three categories are identical to the Case I estimated acreages. The areas in the last two categories were estimated as 20,015 acres of SPG-5 forested wetlands and 74,496 acres of SPG-6 forested wetlands. The land in the last three categories, the total converted wetlands acreage, has a total area of 112,201 acres.

Case III. It was assumed that 70% of all privately owned forested wetlands in the floodplain would be converted to agricultural use following the channelization project. The assumption was also made that the land conversion would proceed in a rational manner; that is, all forested wetlands on SPG-5 soils and SPG-6 soils would be converted to agriculture before the conversion of wetlands on SPG-7 soils because of their relatively low productivity. The area involved was estimated to include all SPG-5 and SPG-6 wetlands and 52,416 acres of SPG-7 forested wetlands. This case thus included the five categories of land identified in Case II plus a sixth category, the converted SPG-7 wetlands. The total wetlands conversion in this case was 164,617 acres.

RESULTS

Estimated Net Development Values

The net development values estimated for the various assumed levels of land use change, output price sets, and discount rates considered in this study are presented in Table 5.

The development values estimated for each case increased with output price level as was expected. In comparing the development values estimated for the three cases it was found that the Case II estimates exceeded the Case I estimates at the high median and high output price levels. It was also found that the Case III estimates were less than the Case II estimates at all output price levels.

Let us assume that the channelization project is undertaken and that society's goal is to maximize the net returns from this investment. Since Case III differs from Case II only in the development of SPG-7 wetlands, these relationships imply that a policy prohibiting the conversion of SPG-7 wetlands to agricultural use would be in the interest of society. Further, since Case II differs from Case I in the assumed conversion of SPG-5 and SPG-6 wetlands, a policy prohibiting the development of unprotected wetlands would contribute to this goal if output price levels were expected to approximate the low, low median, or average price sets over the planning horizon.

Table 5. Discounted net values of development estimated for three cases and five output price sets, Obion-Forked Deer Floodplain

Case and Price Set[a]	Discount Rate 8%	9%	10%
		Dollars in Millions	
Case I			
Low	7.3	5.2	3.5
Low Median	15.8	12.3	9.7
Average	24.4	19.6	15.9
High Median	33.0	26.9	22.1
High	41.5	34.1	28.3
Case II			
Low	−12.1	−11.3	−10.5
Low Median	4.7	2.9	1.6
Average	21.6	17.7	13.8
High Median	38.4	31.5	26.0
High	55.3	45.8	38.2
Case III			
Low	−27.1	−23.9	−21.3
Low Median	−7.1	−7.0	−6.8
Average	13.1	10.1	7.7
High Median	33.2	27.1	22.2
High	53.3	44.1	36.8

[a] Case I assumed no unprotected wetlands would be developed, Case II assumed the development of all unprotected SPG-5 and SPG-6 wetlands, and Case III assumed the development of slightly less than half of the SPG-7 wetlands in addition to the unprotected SPG-5 and SPG-6 wetlands. The output prices within each set are presented in Table 3.

These policy implications follow logically from the analysis but present an apparent paradox. The differences among the three cases were the assumed acreages of forested wetlands developed for agricultural purposes. Development values were estimated with a static model based upon the net agricultural returns from a representative acre of each soil group.[20] The relationships among these cases then reflect the estimated annual net revenues under flooded conditions presented in Table 6. These estimates imply that the conversion of SPG-5 and SPG-6 wetlands to agricultural use is economically rational only with optimistic crop price expectations

[20] A static model means that all variables were assumed not to change over the planning period. A representative acre is a hypothetical acre of land with an assumed crop distribution pattern in exactly the same proportions as the crop distribution patterns in the area in question. Thus, if 60 acres of a 100 acre floodplain are planted in soybeans, 60% of the representative acre would be allocated to soybeans. In this study, calculations were made on a representative acre basis, and these results were increased by the number of acres in the appropriate SPG; in the above example increasing the representative acre returns by 100 would provide the estimate of the returns from the 100-acre floodplain. Expression 7 of Appendix A was used to calculate the representative acre weights in this study.

Table 6. Estimated annual net agricultural returns from a representative acre under flooded conditions by Soil Productivity Group, Obion-Forked Deer Floodplain

Output Price Set [a]	SPG-5	SPG-6	SPG-7
		Dollars	
Low	−24.70	−30.37	−40.50
Low Median	−10.69	−18.29	−31.70
Average	3.31	−6.23	−22.97
High Median	17.32	5.82	−14.23
High	31.28	17.88	−5.51

[a] The prices within each set are presented in Table 3.

and that the conversion of SPG-7 wetlands is economically irrational under all output price sets considered. The problem arises from the observation that 4,651 acres, 9,878 acres, and 10,837 acres of SPG-5, SPG-6, and SPG-7 wetlands, respectively, were converted to agriculture from 1964 to 1971 (26, p. 29). The conversion of SPG-5 and SPG-6 wetlands to agriculture may be explained by optimistic crop price expectations; however, the conversion of SPG-7 wetlands cannot be explained on this basis unless prices greater than those used in this study are hypothesized. A second possible explanation for this apparent paradox is that annual flood probabilities are based upon long run calculations. Observed flooding below these computed averages may create expectations which induce landowners to convert wetlands to agricultural use for short run gains.

A second paradox was apparent in the study results. The discounted development values attributable to channel modification, Case I, exceeded the discounted development costs at all output price levels; note that all the values for Case I in Table 5 are positive. Why then have not the owners of the land which would be enhanced by channel modification undertaken the channelization themselves?

Three possible explanations may be mentioned. First, this analysis considered only one use of the limited capital available to the landowner while a number of alternative investment opportunities presumably exist. Channelization would be deferred until those investments which promise greater returns have been undertaken. A second possible explanation involves the difficulties of group action. The cost of transactions among participants and various games of strategy are widely recognized impediments to action by large groups. In addition, channel modification is somewhat unique in that the benefits could not be restricted solely to participating landowners. This characteristic provides an incentive to remain outside the group and share in the benefits without sharing the costs. Third, the Obion-Forked Deer channelization project was authorized in 1948 (21, p. 1). The expectation of public funding would presumably tend to dissuade landowners from undertaking the project at their own expense. Such deferment may not be permanent; continued failure to fund the authorization might induce property owners to incur the project cost themselves rather than continue to bear the costs implicit in foregoing the benefits of the project.

Let us assume that the best social use of the area is as forested wetlands. Alternative uses for private capital and the expectation of public funding would appear to produce only a short run postponement. These hindrances might presumably be surmounted.[21] These considerations suggest that public action would be required to prevent private channelization and thus assure optimality.

The economic feasibility of channelization by a group of landowners also raises the question of the appropriateness of public involvement. Public investment is frequently justified with the previously discussed assumption that a gain or loss to an individual is a corresponding gain or loss to society. It is presupposed, of course, that no alternative investments with greater returns are available. A large net return from channel modification would not however, appear to be sufficient reason for public financing.

Let us temporarily assume that no externalities are associated with channelization and the following land use changes. Public financing could be justified if the landowners would not undertake the project at their own expense. Public funds might best be used, however, to remove the impediments to channelization by the owners of enhanceable property.[22] Assume this alternative is chosen and, as a result, the landowners undertake the project. The public sector would in effect gain the difference between the cost of channelization thus avoided and the cost incurred in fostering this private effort. The alternative chosen would appear to depend upon the probabilities of successfully aiding private action and the positive magnitude of the implicit gain in the public account.

Alternatively, the returns from channelization may exceed its

[21] The problem of the free rider, for example, may be solved by transforming the group into a legal entity with the power of taxation. Brown (4, pp. 21-30) discusses this solution as well as many other aspects of channel modification considered in this discussion.

[22] For example, public assistance in the formation of a private channelization corporation could remove the barriers to private action.

cost by an amount great enough to induce the landowners to undertake the project, overcoming any obstacles on their own. In this case, public involvement would be justified if the public sector were more efficient than the private sector and, therefore, could complete the project at a lower cost. Society would in effect gain the difference in the cost of the project as a public undertaking as opposed to a private undertaking since the channels will be modified regardless of the source of funds.[23] This difference would appear to be the relevant decision parameter; public financing would be economically justified if no alternative public investment would yield returns greater than this difference in cost.

Finally, public funding of the channelization project could be justified as a means of providing public assistance to one group within society. Let us suppose that society decides that the owners of enhanceable property are deserving of public assistance. The decision to publicly finance channel modification would then be a question of whether there are more appropriate or more efficient methods of providing aid to this group.

Relaxing the assumed absence of externalities would not appear to strengthen the argument for public financing of the project. External economies can provide a rationale for public investment; however, the identified externalities were diseconomies associated with channelization and resulting wetlands loss. The theoretically correct role for the public sector in such a case is to represent those people whose interests would be adversely affected by the project. While the limited incidence of benefits may be an argument for local financing, the wider incidence of external diseconomies is an argument for social control over the decision regardless of the source of funds.[24]

Estimated Preservation Values

The partial estimates of the social value of the current environment which would be foregone if the floodplain were developed for agricultural purposes, the preservation values, for the various assumed levels of land use change, value sets, and discount rates considered are presented in Table 7.

The preservation values estimated for each case increased with the valuation level as was expected. However, the relationships between cases did not coincide with *a priori* expectations at the

[23] In the prior case, the value of any such difference in efficiency would reduce the gains from fostering private action.

[24] The potential impact on migratory waterfowl give an international dimension to these externalities. The correct jurisdiction for the decision may be multi-national rather than national.

Table 7. Preservation values estimated for three cases and six valuation levels, Obion-Forked Deer Floodplain

Case and Valuation [a]	Discount Rate 8%	9%	10%
	Dollars in Millions		
Case I			
Low (WRC)	14.4	12.2	10.4
Average (WRC)	20.9	17.7	15.1
High (WRC)	27.4	23.1	19.8
Low (UCOWR)	15.3	12.9	11.0
Average (UCOWR)	21.8	18.4	15.7
High (UCOWR)	28.2	23.9	20.4
Case II			
Low (WRC)	8.1	6.8	5.9
Average (WRC)	17.4	14.7	12.5
High (WRC)	26.6	22.5	19.2
Low (UCOWR)	14.1	11.9	10.2
Average (UCOWR)	23.5	19.8	16.9
High (UCOWR)	32.8	27.7	23.7
Case III			
Low (WRC)	4.7	3.9	3.4
Average (WRC)	15.4	13.0	11.1
High (WRC)	26.1	22.1	18.9
Low (UCOWR)	13.5	11.4	9.7
Average (UCOWR)	24.4	20.6	17.6
High (UCOWR)	35.3	29.9	25.5

[a] Case I assumed no unprotected wetlands would be developed, Case II assumed the development of all unprotected SPG-5 and SPG-6 wetlands, and Case III assumed the development of slightly less than half of the SPG-7 wetlands in addition to the unprotected SPG-5 and SPG-6 wetlands. The values within each set are presented in Table 4.

four lowest valuation levels. Increasing the amount of converted wetlands would be expected to increase the associated opportunity cost yet the opposite relation was found between the three cases at these valuation levels. These results may be rationalized by the forestry values used in the analysis. The procedure used to compute the value of a representative acre of forested wetlands produced negative values. Thus, clearing additional forest reduces the computed foregone benefits.

The relations between cases at the Average (UCOWR) and High (UCOWR) valuation levels do coincide with *a priori* expectations. These results may be rationalized by the magnitudes of the values attributed to a specialized recreation activity day at these levels of valuation.

The UCOWR values for a specialized recreation activity day, \$15.00, \$17.50, and \$20.00, are significantly larger than the WRC values, \$2.50, \$4.75, and \$7.00. Use of the UCOWR values rather than the WRC values did not create as large a divergence between the preservation value estimates as might be expected from a comparison of their relative magnitudes. These results may be attributed to the number of specialized recreation activity days estimated for the floodplain. The choice of recreation values may have been of greater significance if greater numbers of specialized recreation activity days were involved.

Comparisons of Estimated Development and Preservation Values

According to the logic of the decision criteria, channelization and the resulting land use changes are economically justified if the discounted value of the resulting net income stream exceeds the discounted value of the foregone net benefits from the wetlands environment. Maintenance of the wetlands environment is economically justified if the opposite relationship exists.

Development values were estimated at five crop price levels and preservation values were estimated at six levels of valuation in the study. While all possible comparisons might be enlightening, it has been argued that, when dealing with an irreversible alternative, adjustments should be made to reflect the loss of options involved in a decision (8, p. 609). Technical and biological data examined in this study suggested that wetlands conversion through channelization is essentially irreversible. A current land allocation decision could presumably prove incorrect in the future because of unforeseen events. An error because of the possible overvaluation of the preserved environment would not eliminate the option of channelization at some future time. Development through channelization would, however, apparently eliminate the option of the preservation alternative if future events indicate that woodlands represent the optimal land use. A single set of comparisons, employing the preservation values estimated at the highest valuation level, was therefore made.[25]

[25] The concept of irreversibility is also a justification for the method of quantifying wetlands benefits employed in the study. Krutilla (12, p. 785) has noted that irreversible environmental decisions are similar in concept to a dynamic linear programming problem which requires that current actions be compatible with the attainment of a desired future state even though they may not coincide with the actions which are optimal under current conditions. He also observes that, while the optimal amount of natural environments is unquantifiable with the current state of knowledge, it is probably increasing over time (12, pp. 785-786). The measurement of sustained productivity implies that the renewable resource in question has a value independent of current utilization which should be included in decisions on irreversible environmental transformations. These computations were based upon estimated sustained productivity under current conditions rather than potential productivity under intensive management to avoid possible unrealistic overinflation of the value of renewable wetlands resources.

The discounted value of preservation estimated at the high (UCOWR) valuation level was found to exceed the discounted net value of development estimated at the low, low median, and average crop price sets in the three cases examined. This set of preservation values was also found to exceed the net value of development estimated at the high median crop price set for Case III.[26]

In terms of the decision criteria, the area should remain as forested wetlands if agricultural output prices over the 50-year planning horizon are expected to approximate these price levels. These results were obtained with an incomplete estimate of the value of preservation. A more complete estimate would probably increase the magnitude of the difference between the values estimated for these two alternatives as omitted parameters would appear to be wetlands benefits lost through channelization and land use change.

The incompleteness of the estimated value of preservation is important for those cases and price sets where the net value of development exceeds the value of preservation. If crop prices are expected to approximate the high median—high range, the land allocation decision becomes a question of judgment. The difference between the discounted value of development and the value of preservation provides a threshold for the decision. If the unquantified, and perhaps unquantifiable, parameters are judged to have a potential social value at least equal to this difference the area should be maintained as wetlands. Development for agricultural purposes is justified if the opposite judgment is made. A list of potentially important parameters in this category is presented in the third column of Table 2. These positive differences or threshold values are presented in Table 8.

The differences estimated for Case II would appear to be the relevant threshold values for the land use decision. The net development benefits estimated for Case II exceeded the Case I estimates at the high median and high crop price levels. Thus, if the streams were channelized, society would not receive the maximum possible net benefits if land conversion were limited to lands enhanced by the project. Similarly, maximum obtainable social benefits would not be realized if the conversion of SPG-7 land assumed in Case III were undertaken.

Let us assume that crop prices are expected to be within the high median—high range and that an acceptable mechanism for social

[26] Comparison at the high (WRC) valuation level changes the direction of the inequality only for the Case III development values estimated at high median crop prices.

Table 8. Threshold Values: The positive differences between the net present value of development and the present value of preservation at the high (UCOWR) valuation level

Case and Output Price Set [a]	Discount Rate 8%	9%	10%
	Dollars in Millions		
Case I			
High Median	4.7	3.0	1.7
High	13.3	10.2	7.9
Case II			
High Median	5.6	3.8	2.3
High	22.5	18.1	14.5
Case III			
High	18.0	14.2	11.2

[a] Case I assumed no unprotected wetlands would be developed, Case II assumed the development of all unprotected SPG-5 and SPG-6 wetlands, and Case III assumed the development of slightly less than half of the SPG-7 wetlands. The output prices within each set are presented in Table 3.

decision making exists. In this situation, the estimated differences between the discounted net development value and preservation value for Case II are approximately \$4 million at the high median price set and about \$18 million at the high price set with the 9% discount rate. Let us also assume a social consensus that the unquantified wetlands benefits have a present value to society of at least \$4 million but do not have a present value greater than \$18 million.[27] It may be possible to establish a definite point between these two values where a marginal change in the threshold value will alter the optimal land use. It would appear likely, however, that a diversity of opinion would exist. The outcome would not be a definite point but a range of values within which the correct land allocation decision is uncertain. A possible decision guideline in this event would be the concept of maintaining the maximum number of options open when dealing with irreversible environmental transformations. This concept would suggest preservation of the wetlands until the uncertainty is resolved.

The Value of Flooded Wetlands

The results of the analysis raised the question of the optimal use of floodplain lands without channel modification. The data presented in Table 6 indicate that the dedication of SPG-5 wetlands to agriculture will yield positive returns at the average, high median,

[27] A 50-year annuity of approximately \$156,000 has a present value of one million dollars at the nine percent discount rate. A 50-year annuity of approximately \$133,000 and \$182,000 is required per million dollars in present value at 8% and 10%, respectively.

and high crop price sets and that the conversion of SPG-6 wetlands will yield positive returns at the high median and high price sets. Let us assume that crop prices are expected to approximate these ranges; a private landowner would then rationally convert his SPG-5 and SPG-6 wetlands holdings to agriculture.

The optimal social land use may be evaluated by comparing the estimated net agricultural returns with the estimated net annual value of forested wetlands. This comparison was made with the wetlands value estimated at the high (UCOWR) valuation level, $14.60. This value exceeded the net agricultural returns from a representative acre of SPG-5 land under flooded conditions estimated at the average crop price set. This value also exceeded the net agricultural returns from a representative acre of SPG-6 land under flooded conditions estimated at the high median crop price set. These relationships imply that maintenance of the wetlands on these soils would be the optimal social policy under these crop price conditions. Public land use controls would appear necessary since the market would provide the individual owner with economic incentive for wetlands conversion.

The net agricultural returns from a representative acre of SPG-5 land estimated at the high median and high crop price sets exceeded the estimated net annual value of forested wetlands. This relationship was also found for a representative acre of SPG-6 land when the agricultural returns were estimated at the high crop price set. The incompleteness of the wetlands valuation again makes the optimal land use a question of judgment in these cases. The differences between the estimates were $3.28 for a representative acre of SPG-6 land at the high crop price set and $2.72 and $16.68 for a representative acre of SPG-5 land at the high median and high crop price sets, respectively. Optimality would require the prevention of the agricultural use of these two soil groups if the unestimated wetlands parameters were judged to equal or exceed these differences.

Social Acceptability

The policy implications of the analysis discussed in the preceding sections did not consider the question of social acceptability. This question does merit consideration however since the implementation of policy depends to some degree upon social acceptability and the better land use alternative is not, of necessity, socially acceptable.

The core of the problem is the divergence of costs and benefits. Let us assume that the preservation alternative has the greater opportunity cost. The potential income from the use of the land for agricultural production foregone through maintaining the wetlands-forest environment is a cost borne by the landowner while a major share of the benefits accrue to other members of society. While some social observers have reportedly found indications of changes in the values associated with private property, the traditional values associated with property ownership would still seem to prevail; the argument that the individual landowner who is sacrificing potential income for the public welfare will, as a member of society, ultimately accrue greater benefits if his holdings are dedicated to their best social use, would probably receive minority support. Greater support might be obtained for providing compensation to the landowner for the income foregone in the interest of society.

If the better land use would be unacceptable because the distribution of resulting costs and benefits is judged unfair or unjust by society, then it would appear necessary to explore alternative methods of redistribution to remove this barrier to better land use. The public sector could, for example, represent society and pay the landowner the estimated value of the nonmarket products produced by his wetlands. The public sector might in return receive a use easement on the property.

Let us now assume that the development alternative is the better land use. The divergence of costs and benefits associated with this alternative might well be socially acceptable and not hinder the land use change. If, however, the question of distribution were a problem, its resolution might prove more difficult than in the former case. First, identifying the people who bear the costs of the foregone wetlands environment would be considerably more difficult. Second, the form the compensation should take could prove difficult since the cost is not foregone income but foregone environmental products which are valued for themselves rather than for their monetary equivalents.

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APPENDIX A

ANALYTICAL PROCEDURES

Theoretical Model

THE VALUE OF LAND in alternative uses was the central element in the analysis. This value was defined as the present value of the stream of net returns from a particular plot of land in its best use.

Private Land Values

Let us first consider the value of an acre of wetlands best used to produce forest products to the individual landowner.[1] Defining the discounted net returns as V_1, the value of this acre may be expressed as:

$$(1) \qquad V_1 = \sum_{t=1}^{n} \frac{P'_t F_t - C'_t}{(1+r)^t}$$

where: P'_t = the price per unit of forest products in year t

F_t = the quantity of forest products harvested in year t

C'_t = the cost of producing F_t

r = the interest rate, and

t = the planning horizon.

Let us now assume that the channelization of the adjacent streambed will reduce the incidence and duration of flooding sufficiently to make crop production the best land use. The present value of this acre of land to the landowner following channelization (V_2) may be written as:

$$(2) \qquad V_2 = \sum_{t=1}^{n} \frac{P_{it} Q_{it} - C_{it}}{(1+r)^t}$$

where: P_{it} = the price per unit of crop i in year t

Q_{it} = the yield per acre of crop i in year t

C_{it} = the cost of producing Q_{it}

and all other parameters are as previously defined.

Under what economic conditions would the landowner support the proposed project? Let the cost of the project to the landowner have a present value of C. The landowner would support the proposal if $V_2 - C$ is greater than V_1; that is, if the net returns

[1] Brown (4), Goldstein (9), and Krutilla (13) were instrumental in the formulation of the following model. It was assumed throughout the analysis that all parameters are constant over time. This assumption eliminates uncertainty of the future; present values are thus known, not expected.

after channelization exceed the net returns before channelization. This decision rule may be expressed as the inequality:

$$(3) \qquad V_2 - C \gtrless V_1$$

If the value of the land after channelization, $V_2 - C$, exceeds the value of the land before channelization, V_1, the project would be undertaken. If the opposite inequality holds, the project would not be undertaken.[2]

Social Land Values

Equations (1) and (2) would also express the value of an acre of land to society if no external effects were associated with the alternative land uses.[3] Externalities are associated with these alternatives, however, and a social land value model was constructed by introducing values external to the individual private property owner into expressions (1) and (2). A search of the literature identified a number of possible externalities which were grouped into three categories: estimated externalities, unestimated externalities, and externalities eliminated from consideration in the study because of the lack of evidence of their existence and/or conflicting evidence.

Introducing the externalities in the first two categories into expressions (1) and (2), the present value of an acre of land dedicated to agriculture to society (DV) may be expressed as:

$$(4) \qquad DV = \sum_{t=1}^{n} \frac{P_{it} Q_{it} - C_{it}}{(1+r)^t}$$

with all parameters as previously defined.[4] The discounted value of

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[2] In the case of an equality, of course, no net gains accrue from either decision and the individual property owner would be indifferent to the proposal.

[3] It must be assumed that an individual's gain or loss is a corresponding social gain or loss for this statement to be valid. This implies a constant, identical marginal utility of money which has been criticized as being inferior to identifying the distribution of gains and losses within society and weighing them by individual utility levels (16). This approach, however, would require cardinal measures of utility in order to make comparisons among gainers and losers and such measures are not reliable. To avoid these difficulties in measurement, a constant and equal marginal utility of money was assumed.

[4] Comparing expressions (2) and (4), it is obvious that any externalities arising from the use of land for agriculture were considered negligible or within socially acceptable limits. The development value, DV, will be under estimated if socially significant external economics are associated with the use of the land for agriculture and overestimated if significant diseconomies are associated with this land use.

wetlands preservation to society (PV) may likewise be expressed as:

$$(5) \qquad PV = \sum_{t=1}^{n} \frac{F_t + F'_t + R_t - C_{pt}}{(1+r)^t}$$

where: F_t = the per acre value of forest products in year "t"

F'_t = the value of forest products produced on other land in year "t" dependent upon the water relations of the wetlands environment

R_t = the per acre value of the fish and wildlife dependent upon wetlands habitat in year "t"

C_{pt} = the per acre costs associated with the production of these wetlands products

and all other parameters are as previously defined. Note that the preservation value, PV, is an estimate of the social cost of land use change following channelization. A different set of externalities may be associated with an alternative development measure, such as the construction of a dam. An expression of the value of preservation would correspondingly change. Also, PV is not an estimate of the total value of the wetlands to society. The social value of wetlands would include the total value of flood damage. The relevant decision parameter for inclusion into expression (5) is the change in flood damage produced by a particular modification of the stream channel. These two values do not necessarily coincide.

Defining CD as the present value of the cost of development, the social decision criteria may be written as:

$$(6) \qquad DV - CD \gtrless PV$$

The left hand expression is an estimate of the net value of development and represents the benefits which would be foregone if an acre of wetlands were maintained. The right hand expression is an estimate of the net value of the wetlands which would be foregone if the area were dedicated to agriculture. Let us assume a wetlands area amenable to agricultural use following channelization of the adjacent stream. Agriculture would be the optimal use of this land if the discounted stream of social benefits from agriculture (DV) less the cost of channelization (CD) exceeded the discounted value of the foregone stream of social benefits from the wetlands (PV). If the opposite inequality holds, the area should remain as wetlands; channel modification would enhance the quality of the environment for agricultural purposes at the expense of an incompatible set of purposes which make a relatively greater contribution to the total well-being of society.[5]

Computational Model

The analysis involved estimating the parameters DV, CD, and PV in order to determine the direction of the inequality in expression (6). Equations (4) and (5) were modified for these estimates and equations for estimating project costs were determined.

Discounting Procedure

The magnitude of the project affected present value calculations. The proposal involves modifying the main channels and major tributaries of the Obion and Forked Deer Rivers for an aggregate length of approximately 160 miles and would require an estimated 11 years to complete (21, p. 3).[6] Some land would presumably be enhanced by the work completed in each year and, therefore, portions of the total benefit and cost streams would begin to accrue throughout the 10-year construction time span.

Data on the cost of project design and construction presented in Appendix Table B-4 were used as proxy variables for annual work completion. It was assumed that the proportion of the total construction cost budgeted for a given year was identical to the proportion of the total project completed during that year. An equality between the assumed proportion of the project completed in a year and the proportion of all benefit and cost streams was also assumed. It would appear unlikely, however, that land which is enhanced by construction in a given year would be cleared and planted in that year. Thus, a one year lag between construction and the start of the agricultural income stream from the land was assumed. Further, the stream of foregone benefits from the land as wetlands was assumed to coincide in time with the agricultural income stream.

The present value of an annuity beginning at some point in the future is computed by calculating the present value of the annuity in the year in which it begins and, then, discounting this value to the present time as a lump sum. This calculation may be made by computing the present value of a $1 annuity beginning in the year in question and then multiplying the annual value of the annuity by this discount factor. This procedure was used in the analysis.

The initiation of portions of an annuity over the 10 years

[5] In the case of an inequality, society would be indifferent. The land use change would have no net impact on social welfare.

[6] Planning and design work alone are scheduled for the first year.

allowed for construction results in ten distinct value streams. The calculation of the present value of a benefit or cost stream associated with the project involved four steps: a) estimating the annual value of the total annuity, b) estimating the portion of this total annuity beginning in each year by multiplying by the assumed annual percentages of project completion, c) multiplying each of the ten resulting values by the present value of a $1 annuity beginning in the appropriate year, and d) summing the resulting present values.

The Value of Development (DV)

In addition to lowering probability of flooding so that wetlands may be used for agriculture, altering the Obion-Forked Deer stream channels will also enhance the productivity of some land already in cultivation. Such land produces below its potential because of a combination of flooding and a high groundwater table, and channelization will reduce if not eliminate these problems. In recognition of these benefits to land already in cultivation, the yield and cost parameters were defined as the change in yield and the associated change in production costs following channel modification. In the case of converted wetlands, the changes in yield and in production costs would equal the total value of the parameter.

An estimate of the distribution of land among the various crops was also needed in order to estimate the value of the benefit stream. For this purpose a crop distribution pattern for each soil productivity group (SPG) was estimated. This was necessary because the crop distribution will vary among the three soil groups in response to differences in the agronomic characteristics of each SPG. The crop distribution parameter was defined as:

$$(7) \qquad A_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}}$$

where: A_{ij} = the expected proportion of SPG-j land dedicated to crop i

C_{ij} = the number of acres of SPG-j dedicated to crop i

n = the number of crops found in SPG-j

Incorporating these changes, the present value of a representative acre of SPG-j land benefited by channelization in year y was estimated with the following equation:

$$(8) \qquad DV_{jy} = \sum_{i=1}^{n} \left(A_{ij} \left(P_i dQ_{ij} - dC_{ij} \right) \right) D_y$$

where: dQ_{ij} = the change in yield per acre of crop i on SPG-j land

dC_{ij} = the change in production costs

D_y = the present value of a dollar annuity beginning in year y

and all other parameters are as previously defined.

The number of acres of SPG-j land converted from wetlands to agricultural use in year y was estimated as:

$$(9) \qquad N_{jy} = (TW_j)\ (B_{y-1})$$

where: TW_j = the estimated total acreage of wetlands on SPG-j soil converted to agricultural use as a result of the project

B_y = the percentage of the total construction completed in year y, and

$y = 2, 3, \ldots 11.$

The assumed 1-year lag between construction of a portion of the project and the start of the agricultural income stream is created by the values of y expressed in this equation.

The number of cultivated acres of SPG-j land enhanced in year y was defined as:

$$(10) \qquad M_{jy} = (TA_j)\ (B_{y-1})$$

where: TA_j = the estimated total acres of SPG-j soil cultivated prior to channelization benefited by the project, and

$y = 2, 3, \ldots 11$

In the analysis, DV_{jy} was estimated for all j and all y. These representative acre values were then increased by the corresponding estimated number of converted wetland acres (N_{jy}) and the enhanced cultivated acres (M_{jy}). The summed products are an estimate of the discounted value of the land use benefits arising in each year of the time span of construction. The total present value of the land use benefits from the project (DV) was then estimated by summing over years and summing over soil groups. These calculations may be expressed as:

$$(11) \qquad DV = \sum_{j=5}^{7} \sum_{y=2}^{11} (DV_{jy}\, N_{jy}) + (DV_{jy}\, M_{jy})$$

with all terms as previously defined.

The Costs of Development (CD)

The channelization project involves three types of costs: the cost of design and construction, the cost of the required land, and the cost of channel maintenance. The total cost of development, CD, was calculated by estimating the present value of each type of cost and then summing the three values.

The present value of the cost of design and construction, CC, was computed by summing the discounted annual costs. Mathematically this is stated as:

$$(12) \qquad CC = \sum_{y=0}^{10} \frac{AC_y}{(1+r)^y}$$

where: AC_y = the cost incurred in year y
and all other terms have been previously defined.

The cost of land is the second type of cost associated with the project. Land is required to enlarge and straighten the channels and to deposit the dredged soil as well as to provide access to the channels during construction and maintenance work. It was assumed that the land requirements coincided through time with construction. The present value of the cost of the land, CL, was calculated as:

$$(13) \qquad CL = \sum_{y=1}^{10} (RL)\ (TL)\ (B_y)\ (D_y)$$

where: RL = the annual rental value of one acre of land
TL = the total acres of land required
$y = 1, 2, \ldots, 10$

and all other parameters have been previously defined.

The cost of maintenance is the third type of cost associated with the project. The project design provides for periodic removal of silt, drift, and snags, and also the control of vegetation with herbicides (21, p. 10). A one year lag between construction of the channel and the start of the maintenance cost stream was assumed. The present value of the cost of maintenance, CM, was calculated as:

$$(14) \qquad CM = \sum_{y=2}^{11} (AM)\ (B_{y-1})\ (D_y)$$

where: AM = the total annual maintenance cost
$y = 2, 3, \ldots, 11$

and all other parameters are as previously defined.

Finally, the present value of the total cost of development may be expressed as:

(15) $CD = CC + CL + CM$

all parameters having been previously defined.

The Value of Preservation (PV)

The value of fish and wildlife lost through wetlands conversion, parameter R_t of equation (5), was divided into several parameters for estimation. In addition to resident fish and wildlife, the Obion-Forked Deer wetlands provide feeding areas, resting areas, and breeding sites for migratory waterfowl. Two dimensions are suggested: the value of fish and wildlife within the watershed and the value of migratory waterfowl beyond the boundaries of the watershed.[7]

Five parameters were identified for valuation of the fish and wildlife within the watershed: sport fishing, big game, small game including furbearers, waterfowl, and general recreation.[8] The valuation procedure involved a) estimating the maximum sustained productivity of the fish and wildlife in the Obion-Forked Deer floodplain in terms of recreation activity days, b) estimating the losses due to channelization, and c) attributing values to the estimated number of foregone recreation days.

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[7] Estimates of the impact of channelization and land use changes in the Obion-Forked Deer floodplain beyond the boundaries of the watershed were not obtained in the analysis. Research on the quantitative and qualitative impacts of habitat loss on migratory waterfowl is in the incipient stages and models of the dynamics of waterfowl populations have not yet been developed (24, pp. 393-413 and 1,496-1,497). The complexity of prediction is increased by the possibility of the interaction of the wetlands conversion and habitat losses occurring throughout the Mississippi Flyway. The magnitude of the impact of the loss of wetlands habitat in the Obion-Forked Deer would be partly determined by habitat losses in other areas during the planning horizon if the effects do interact. The relevant social opportunity costs identified for this analysis were the losses incurred beyond the boundaries of the watershed as a result of channelization and following land use adjustments within the watershed. A movement to comparable breeding sites and overflight by migrating waterfowl is a possibility; in this case society would incur no such losses. A shift within the migration route with no change in the size and composition is a second possibility. The negative impact in adversely affected regions would be compensated to some extent by the positive impact in other regions; a net gain to society as a whole would be theoretically possible. A final possibility is a decline in the waterfowl population with an accompanying loss to society. In the absence of adequate information to eliminate any of these possible outcomes, this dimension was omitted from the analysis, potentially increasing the incompleteness of the estimation.

[8] The aquatic resources of the watershed support a small commercial fishing industry in addition to sport fishing, however, virtually no data are available. Data from other areas show that it is questionable if the benefits of a fresh water commercial fishery are greater than the correctly calculated costs (5, p. 12). It was assumed that the total costs of the commercial fishery in the Obion-Forked Deer equal the total revenues.

A representative wetlands acre was constructed with the assumption that the value of wetlands does not vary among soil groups. The opportunity cost of converting this representative acre to agricultural use in year y was defined as:

$$(16) \qquad PV_y = (F_1 + F_2 + R_1 + R_2 + R_3 + R_4 + R_5 - C_p)\ (D_y)$$

where: F_1 = the annual value per acre of harvestable forest products

F_2 = the annual value of the change in productivity of the remaining wetlands forest per acre of converted wetlands

R_1 = the annual value of lost sport fishing per acre of converted wetlands

R_2 = the annual per acre value of small game hunting including furbearers

R_3 = the annual per acre value of big game hunting

R_4 = the annual per acre value of waterfowl hunting

R_5 = the annual per acre value of general recreation

and all other parameters are previously defined.[9]

The number of wetlands acres converted to agricultural use in year y was derived from equation (9) by summing over soil groups. The calculation was:

$$(17) \qquad N_y = \sum_{j=5}^{7} N_{jy}$$

In the analysis PV_y was estimated for all y. These representative acre values were then increased by the corresponding estimates of the number of converted wetlands acres (N_y). The product is an

[9] As previously noted, expression (16) is an incomplete expression of the social opportunity cost of wetlands conversion. For example, a number of people derive satisfaction from the knowledge that a natural state is being preserved even though they have no direct contact with the area. The observable actions of individuals and groups reveal that this vicarious consumption has a value, however the methodology for measurement and valuation has not yet been developed. The incompleteness of the preservation value will not affect the results of the analysis if the estimated opportunity cost of development exceeds the estimated net value of development (DV — CD). A more complete estimate would only increase the magnitude of the difference and strengthen the economic justification for wetlands preservation. If, on the other hand, the estimated net value of development exceeds the estimated value of preservation the analysis would be inconclusive; the magnitude of the unmeasured, and perhaps unmeasurable, development opportunity costs could be sufficient to justify preservation. The land allocation decision would be a matter of judgment in this case. The difference between the net value of development and the value of preservation would provide a threshold value for the decision. Foregoing the project would be economically justified if it were judged that the unmeasured preservation value at the minimum equaled this difference.

estimate of the discounted value of the wetlands benefits lost in each year of the construction time span. The total present value of the social land use benefits from foregoing the project (PV) was then estimated by summing over the years of the time span. These calculations may be expressed as:

$$(18) \qquad PV = \sum_{y=2}^{11} PV_y N_y$$

with all terms as previously defined.

APPENDIX B

DATA SOURCES

The Value of Development (DV)

THE DISCOUNTED REPRESENTATIVE acre values expressed in equation (8) were the central element in the estimation of the present value of development. Calculation of the present value of the benefit stream from a representative acre of SPG-j land beginning in year y of the planning period required estimates of the crop distribution, the prices of the output, the changes in crop yields attributable to the project, and the associated changes in production costs.

Crop Distributions (A_{ij})

The channelization project is expected to enhance the productivity of land in cultivation prior to channel modification and also result in the clearing of forested land for agricultural use. A representative crop distribution was calculated for each SPG using the procedure expressed in equation (7) for each of these two pre-project land uses. Crop distribution weights for land in cultivation prior to the project were calculated from the land use data in Table 1 with the assumption that the distribution of land among the various crops would not change after channel modification. Weights for land cleared following the project were calculated from data on the 1971 distribution of crops on land cleared between 1964 and 1971 (26, p. 29) with the assumption that land converted to agricultural use following channel modification would be allocated among the various crops in the same proportions as the land cleared during this period. The two sets of representative acre crop distribution weights calculated for each SPG are presented in Table B-1.

Output Prices (P_i)

Five sets of crop prices were used in the analysis. The price sets were constructed by: 1) establishing an assumed price range for soybeans, corn, cotton, and pasture, 2) identifying five points within the range for each crop—the high, average, and low price and the midpoints between the average price and the high and low prices, and 3) grouping the corresponding points of each price range. The five resulting sets of output prices are presented in Table 3.[1]

Table B-1. Representative acre weights by soil productivity group computed from 1971 crop distributions, Obion-Forked Deer Floodplain

Crop	Entire Floodplain			Forest Land Cleared Between 1964 and 1971		
	SPG-5	SPG-6	SPG-7	SPG-5	SPG-6	SPG-7
	Acre Weights					
Soybeans	0.707	0.861	0.826	0.972	0.959	0.957
Corn	0.051	0.025	0.029	0.005	0.007	0
Cotton	0.041	0.017	0.015	0.005	0.002	0.002
Pasture	0.161	0.067	0.076	0.009	0.015	0.025
Miscellaneous [a]	0.040	0.030	0.054	0.009	0.017	0.016

[a] Includes rice, milo, small grains, truck crops, and idle cropland.

Prices for the miscellaneous cropland category, which included rice, milo, small grains, truck crops, and idle cropland, were not estimated. Miscellaneous cropland was arbitrarily assigned a net return 25% less than the average net returns per acre from soybeans, corn, cotton, and pasture for each price set. Any inaccuracy introduced into the analysis by this procedure was believed to be minor for the crops in this category would appear to represent a relatively minor portion of the total agricultural income stream.

Yield (Q_{ij})

Yields per acre were estimated for each SPG under both flooded and flood-free conditions. The soybean, corn, and cotton yields were derived from working papers of the USDA survey of the Basin (30, pp. 8-9). The pasture yields were derived from data developed at the University of Tennessee (1, p. 38). These yield data are presented in Table B-2.

The changes in yield on land cultivated prior to channelization and enhanced by the project were assumed to equal the differences between the estimated flooded and flood-free yields. The yields on land not cultivated prior to channelization and enhanced by the project were assumed to equal the estimated flood-free yields while the yields on land not cultivated prior to channelization and enhanced by the project were assumed to equal the estimated yields under flooded conditions.

[1] The representative acre weights were derived from 1971 cropping patterns and, therefore, depend upon particular input and output price relations. The representative crop distribution may not correspond to the profit maximizing distribution for the five output price sets used in estimating the model.

Table B-2. Estimated average flood-free and flooded crop yields per acre by soil productivity group, Obion-Forked Deer Floodplain

Crop	Flood - Free			Flooded		
	SPG-5	SPG-6	SPG-7	SPG-5	SPG-6	SPG-7
	Yield per Acre					
Soybeans (bu.)	30	26	19	19.8	17.2	12.5
Corn (bu.)	65	60	38	42.9	39.6	25.1
Cotton (lb.)	750	705	556	555	521.5	496
Pasture (grazing days)	180	160	140	126	112	98

Sources: Pasture yields derived from Atchison, J. A. 1972. "A Study of Optimum Resource Use on Part-Time Farms in the Brown Soil and Delta Areas of Tennessee," Unpublished M.S. thesis, University of Tennessee, p. 38.

Soybean, corn, and cotton yields derived from Williams, J. 1972. "The Agricultural Sector of the Obion-Forked Deer Study Area: Working Papers," U.S. Department of Agriculture, Economic Research Service, Little Rock, Arkansas, pp. 8-9.

Production Costs (C_{ij})

The per acre costs of production were derived from budgets developed at the University of Tennessee as a part of Regional Project S-67 (11). These budgets were developed for a region of Tennessee which includes a significant portion of the Obion-Forked Deer Basin and were assumed to be representative of the floodplain. These cost data are presented in Table B-3.[2]

The changes in production costs for land cultivated prior to channelization and enhanced by the project were assumed to equal the differences between the estimated costs under flooded and flood-free conditions. The production costs for land not cultivated prior to channelization and enhanced by the project were assumed to equal the estimated costs of production without flooding while the production costs for land not cultivated prior to channelization and not enhanced by the project were assumed to equal the estimated costs of production under flooded conditions.[3]

[2] These estimates include the cost of fixed and variable inputs, a $1.60 per hour labor cost, a return to management of 5% of the estimated total revenue per acre, a $9.81 per acre general overhead cost and an average land cost of $25.37 per acre. The estimates were computed for a 180-acre farm, the average farm size in the 14-county area which contains the watershed (3, p. 34).

[3] The per acre costs of land clearing were assumed to equal the value of the resulting timber throughout the analysis. The stumpage value of the timber on an average acre was estimated to be approximately $200.00 (1971 dollars).

Table B-3. Estimated average annual production costs per acre by soil productivity group, flood-free and flooded conditions, Obion-Forked Deer floodplain [a]

Output Price Set and Crop	Flood-Free SPG-5	Flood-Free SPG-6	Flood-Free SPG-7	Flooded SPG-5	Flooded SPG-6	Flooded SPG-7
	Dollars					
Low						
Soybeans	77.07	75.51	73.72	73.96	73.17	71.73
Corn	96.56	86.78	78.56	92.96	83.47	76.56
Cotton	149.43	143.93	128.83	135.58	129.57	118.57
Pasture	54.11	52.49	51.08	53.84	52.25	50.87
Low Median						
Soybeans	78.20	76.49	74.43	74.70	73.82	72.20
Corn	97.37	87.53	79.13	93.50	83.96	76.87
Cotton	151.12	145.41	130.08	136.82	130.74	119.49
Pasture	54.34	52.69	51.26	54.00	52.39	50.99
Average						
Soybeans	79.32	77.46	75.14	75.44	74.46	72.67
Corn	98.19	88.28	79.60	94.04	84.46	77.18
Cotton	152.81	147.10	131.33	138.07	131.91	120.42
Pasture	54.56	52.89	51.43	54.16	52.53	51.12
High Median						
Soybeans	80.45	78.44	75.85	76.18	75.11	73.14
Corn	99.00	89.03	80.08	94.57	84.95	77.50
Cotton	154.49	148.68	132.58	139.32	133.09	121.34
Pasture	54.79	53.09	56.51	54.31	52.67	51.24
High						
Soybeans	81.57	79.41	76.57	76.93	75.75	73.61
Corn	99.81	89.78	80.55	95.11	85.45	77.81
Cotton	156.18	150.27	133.83	140.57	134.26	122.27
Pasture	55.01	53.29	51.78	54.47	52.81	51.36

[a] The returns to management were computed as 5% of the total revenue, creating the variation among price sets. The variation between costs under flood-free and flooded conditions within a price set reflects the difference in returns to management and reduced harvest costs.

Source: Derived from Keller, L. H. and J. A. Atchison, 1972. Unpublished data, University of Tennessee, Department of Agricultural Economics and Rural Sociology.

The Costs of Development (CD)

The present value of the cost of the channelization project was computed by summing the discounted estimates of the three types of costs involved in the project. This procedure is expressed in equations (12) through (15) in Appendix A.

The Cost of Construction (CC)

The estimation of the cost of modifying the Obion-Forked Deer stream channels was based upon estimated annual design and construction costs (21, p. 10). The original values were converted to 1971 dollars with a composite construction cost index (22, p.

677). The resulting annual values, which are given in Table B-4, were discounted at the three alternative discount rates and summed following the procedure expressed in equation (12).

Table B-4. Estimated annual costs of project design and construction and annual construction cost as a percentage of the total construction cost

Year	Cost in Dollars [a]	Percentage
0	283,500	[b]
1	648,000	4.5
2	1,294,380	8.9
3	1,134,000	7.8
4	1,134,000	7.8
5	1,134,000	7.8
6	1,458,000	10.2
7	1,782,000	12.3
8	1,944,000	13.4
9	1,944,000	13.4
10	2,010,420	13.9
Total	14,766,300	100.0

[a] Values are in 1971 dollars as computed with a composite construction cost index (22, p. 677).

[b] No construction is scheduled for year zero.

Source: Derived from U.S. Army Corps of Engineers, Office of the District Engineer, Memphis, 1960. "West Tennessee Tributaries General Design Memorandum No. 1: Revised." Memphis, Tennessee, p. 10.

The Cost of Land (CL)

The project will require unencumbered rights of way to 9,280 acres of land with an estimated annual value of $9.51 per acre (21, p. 8).[4] The portion of this acreage required for annual construction was assumed to equal the portion of the total construction undertaken in a year. The cost data used as a proxy variable for annual construction in the analysis are presented in Table B-4. Following the procedure expressed in equation (13), the product of the estimated total annual land value and the annual proportions of total construction was discounted at the three alternative discount rates and summed.

Not all of the required land will be used in enlarging the channels; some portion will continue to produce wetlands products after construction. Also, the original channels bypassed in straightening stream courses represent a potential increase in land area. It was not possible to estimate the land area lost in channel modifica-

[4] It was assumed that the total area would be required through the life of the project; available project data were not specific on this point. The annual land value was derived from project design data (21, Appendix I) and data developed at The University of Tennessee (11).

tion. It was judged preferable to underestimate rather than overestimate the value of preservation and none of this area was subtracted in estimating the losses associated with the project.

The Cost of Maintenance (CM)

Maintenance of the project channels will cost an estimated $122,000 annually (21, p. 10). This value was converted to 1971 dollars with the composite construction cost index used to inflate the cost of construction (22, p. 677). It was assumed that this estimated cost, $197,640, would begin to accrue in proportions equal to annual construction with a one year lag. Following the procedure expressed in equation (14), the portions of this cost stream beginning in years two through eleven were estimated with the proxy values for the annual proportion of total construction given in Table B-4, discounted, and summed.

The Value of Preservation (PV)

The discounted representative acre values expressed in equation (16) were the central element in the estimation of the present value of preservation. The calculations required estimates of the value of forests and the impact of channelization on forest productivity, parameters F_1 and F_2, the value of fish and wildlife, parameters R_1 through R_5, and the associated costs, parameter C_p.[5]

The Cleared Forest (F_1)

The value of a representative acre of forest to society was defined as the net annual return from the maximum sustained forest production. The average annual net increment in the growth of the

[5] The five R parameters were estimated in a similar manner using the concept of the maximum sustained yield of a renewable resource. Data from the Tennessee Fish and Game Commission were used to estimate the sustained productivity of the fish and wildlife in the Obion-Forked Deer floodplain and to convert these estimates into recreation activity days (2). Sport fishing, small game hunting, and general recreation were assumed to be non-specialized recreation while waterfowl and big game hunting were judged to be activities involving relatively limited opportunities and were valued as specialized recreation. The values proposed by the Water Resources Council (WRC) per day of specialized and non-specialized recreation were used in activity valuation (28, p. III-17). Specialized recreation was also valued at the higher levels recommended by the University Council on Water Resources (UCOWR) (5, p. 15). It was assumed that the costs of producing the fish and wildlife of the floodplain equaled zero. The production costs would appear to be limited to the costs incurred by State and Federal agencies in the management of these renewable resources. It is difficult to assign these costs to a set of species in a specific area; agency budgets would presumably not decline if these species were reduced in numbers. The parameter C_p was then estimated for the costs of forestry production alone.

Obion-Forked Deer floodplain forest is estimated to be about 58 cubic feet per acre (26, p. 11). The estimated range in stumpage value of this net growth was $13.44 to $16.80 per acre in 1971 dollars.[6] Calculations were made with these two values and their simple average, $15.12.

The stumpage value represents total returns less the costs of harvest. Net returns were computed by subtracting the estimated annual cost of the land ($9.51 per acre), the annual costs of general overhead estimated in developing the crop budget ($9.81 per acre), and 5% of the stumpage value as a return to management. The results were the negative returns of $6.55, $4.96, and $3.36 per acre for the low, average, and high stumpage values, respectively.[7]

The Remaining Forest (F_2)

The reduction in frequency and duration of overflows following channel modification decreases the growth of bottomland forests through the reduction in soil moisture. A 50% decline in productivity has been estimated for forests on the Obion-Forked Deer floodplain soil groups (2, p. 14 and p. 25). The net value of this decrease in productivity, about 29 cubic feet per year, was estimated to be $6.39, $7.19, and $7.98 per acre at the low, average, and high stumpage values, respectively.

This average per acre change in value was assumed to be representative of the impact of channelization on the private forest holdings remaining in each case plus the 11,500 acres of forest in State and Federal lands. This total value was divided among the reclaimed acres in each case in creating the representative acre.[8]

Sport Fishing (R_1)

The aquatic resources in the Obion-Forked Deer channels to be modified in the project can support an estimated 969,200 sport

[6] This price range was derived from data on bottomland forests from the USDA survey of the Basin (26, p. 27) and from the Tennessee Game and Fish Commission (2, p. 26). Stumpage values were converted to 1971 dollars with the wholesale price index for lumber and wood products (25, p. 552).

[7] These losses may be the result of the use of averages. For example, the overhead per acre was calculated by the division of the estimated total overhead for the average farm by the size of the average farm. The portion of the general overhead in reality chargeable to forest holdings may be less than this average value. In addition, the annual overhead of nonfarm forest owners may be less than the values used in the analysis.

[8] The present values calculated with this method and present values calculated with the alternative method of dividing the total annual value among the years of the construction time span and discounting are identical. The method used allowed calculation on a representative acre basis and added symmetry to the computation of development and preservation values.

fishing activity days annually (2, p. 13). A 90% loss following channelization was assumed on the basis of a study of 23 channelized streams in North Carolina (24, p. 39). The estimated annual loss of 872,280 activity days were valued at the low, average, and high levels recommended by the WRC for non-specialized recreation: \$0.75, \$1.50, and \$2.25 per activity day (28, p. III-17). Representative acre values were derived by dividing the total estimated values among the estimated number of reclaimed acres in each case.

Small Game (R_2)

Parameter R_2 was defined to encompass small game including squirrel, raccoon, and rabbit, and furbearers including mink, beaver, and muskrat. Tennessee Game and Fish Commission data on populations, sustainable harvests, and potential harvest per trip were used to estimate an annual 0.36 small game hunting activity days per acre (2, p. 9 and p. 19). It was necessary to eliminate the furbearer dimension of this parameter because of the lack of data on populations and harvests. The estimated annual activity day fraction was valued at the low, average, and high values recommended by the WRC for non-specialized recreation and used as the opportunity cost of converting an acre of wetlands to agricultural use.[9]

Big Game (R_3)

Big game species, deer and turkey, were estimated to have the potential of annually supporting 0.12 hunting activity days per acre on a sustained basis from Game and Fish Commission data (2, p. 13). Representative acre values were computed by valuing this activity at the low, average, and high benefit levels proposed by the WRC for specialized recreation: \$2.50, \$4.75, and \$7.00 per activity day. Valuation was also made at the levels recommended by the UCOWR: \$15.00, \$17.50, and \$20.00 per specialized recreation activity day.

Waterfowl (R_4)

An estimate of 0.49 annual waterfowl hunting trips per acre on a sustained basis was derived from available data (2, pp. 26-27). The assumption of unaltered productivity of unreclaimed areas was maintained in creating representative wetlands acres. The

[9] The implied assumption is that the productivity of the remaining habitat will be unchanged. The opportunity costs may be underestimated by this procedure (29, pp. 29-35).

estimated annual recreation per acre was valued at the six levels utilized in valuing big game hunting.

General Recreation (R_5)

This parameter was defined to include wildlife related activities such as bird watching, wildlife photography, and nature hikes. A ratio of 2.27 general wildlife related activity days per hunting activity day in Tennessee has been estimated (2, p. 8).[10] Representative acre values were computed by summing the estimated annual days of hunting activity per acre, increasing the sum by the factor 2.27, and valuing the resulting estimate with the non-specialized recreation day values used in the analysis.

[10] Other general recreation activities, such as pleasure boating and camping, were not included in deriving this ratio. A relationship between such omitted activities and wildlife could presumably exist; a conservative bias may, therefore, have been introduced into the preservation value estimation.

APPENDIX C

An Alternative View of the Economic Impact of Channelization

A CORRECT ASSESSMENT of any project would obviously consider only the benefits attributable to that project. In practice, however, it may be difficult to identify the changes attributable to a project with certainty. In the first case evaluated in this study, estimates were made for the benefits predicted to accrue from the undertaking—that is, the enhanced productivity of 140,140 acres of cropland and the conversion of 17,690 acres of forested wetlands to agricultural use. Implicitly assumed in this case is that this change in land use is attributable to the channelization project.

However, floodplain property owners have converted forested wetlands to agricultural use without the project. Further, estimates reported in this study show that positive returns are possible under flooded conditions. It may then be hypothesized that the forested wetlands in question exist because of more promising alternative uses for the capital required for land conversion, limited managerial ability, or other causes unrelated to flooding rather than to flood hazard subject to remedy by this channelization project. Attributing the stream of net agricultural returns from former wetlands in flood-free conditions to the project would, given this hypothesis, overstate the benefits of channelization. The proper benefit stream would be the difference between the net returns under flooded conditions and flood-free conditions.

The Corps of Engineers channelization proposal was evaluated with this alternative hypothesis. The net development value was composed of the present value of the stream of net returns from a) the change in yield on the 140,140 acres of land in cultivation prior to the project and b) the difference between the flooded and flood-free yields on the 17,690 acres of forested wetlands which—it is predicted—would be enhanced by the project. The resulting estimates for the average, high median, and high crop price sets are presented in Table C-1.

Table C-1. Discounted net values of development estimated using the change in value of benefitted wetlands, Obion-Forked Deer Floodplain

Price Set [a]	Discount Rate		
	8%	9%	10%
	Dollars in Thousands		
Average	23,925	19,242	15,552
High Median	30,757	25,021	20,487
High	37,599	30,808	25,429

[a] The output prices within each set are presented in Table 3.

The differences between these estimates and the Case I estimates presented in Table 5 range from approximately \$300,000 to approximately \$4 million in present value terms. While these lower estimates did not change the relationships between the net development values and the preservation value, the threshold values were, of course, reduced by the difference between these alternative estimates of the value of development. Thus, while these relative magnitudes were not altered, this view of the economic impact of this proposal may have reduced the threshold value sufficiently to alter the decision on the better social use of the floodplain.

Obviously, in another situation the composition of the benefit streams which may be properly attributed to a set of alternatives may determine the relative magnitudes of the opportunity costs associated with these alternatives and thus eliminate consideration of the incompleteness of certain estimates and threshold values. While the principles involved in determining the composition of a benefit stream are simple and straightforward, their application to a set of "real world" alternatives may be far from simple.

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